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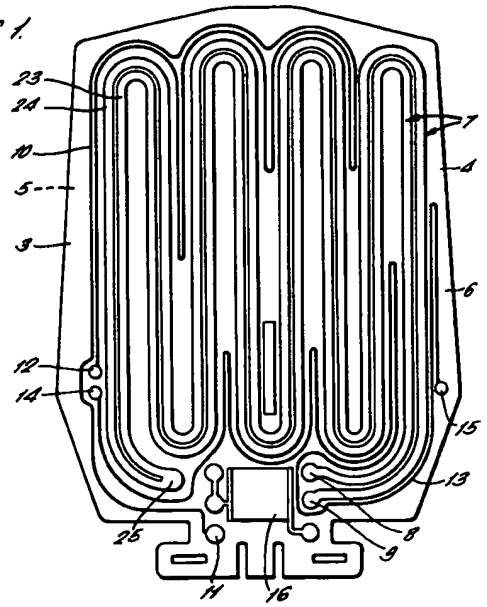
(54) Apparatus for heating liquid.

(57) A vessel (1) contains liquid heated by a liquid heating portion (4) which is an electrically heated substrate constituting an integral part of the vessel. A heater element (7) formed on the substrate comprises a resistive track receiving power from a power control circuit. Temperature sensors (10,13) are provided on the substrate in the form of resistive tracks and a temperature sensing circuit is arranged to turn off the power in response to an increase in temperature of a part of the substrate. Overheating of the heater element is thereby avoided when the vessel is tilted such that part of the liquid heating portion is exposed above the liquid level.

FIG. 1.



EP 0 585 015 A1

This invention relates to apparatus for heating liquid comprising a vessel and a heater element and in particular but not exclusively to a vessel in the form of a kettle for heating water.

It is known to provide heater elements comprising a resistive track applied using thick film circuit techniques to an electrically insulated surface of a substrate. It is proposed in EP-0485211-A that such a heater element should be incorporated into a vessel in order to heat liquid contained within the vessel and that the substrate should define a liquid heating portion of an internal surface of the vessel. It is important to ensure that the heater element does not overheat in use since such overheating can destroy the operability of the element for example by evaporating the resistive track.

It has also been proposed in GB2153190-A to provide a kettle with a thick film circuit heater element suspended within the vessel and provided with a temperature sensor screen printed on the substrate adjacent to the heater track or a looped track of which a part constitutes a temperature sensor track. A disadvantage of such sensors is that they provide temperature sensing in a localised manner whereas the heater track is distributed over a relatively large surface of the substrate.

A heater element incorporated into a vessel such as a kettle is susceptible to any tilting of the vessel which would expose part of the liquid heating portion above the level of liquid in the vessel since this will rapidly result in overheating due to the relatively poor conductivity of air. The tendency for the exposed portion to overheat is also exacerbated by the heater element typically having a positive temperature coefficient of resistance which results in increased heat generation with increased temperature.

According to the present invention there is disclosed apparatus for heating liquid comprising a vessel defining a chamber receiving liquid in use, a substrate defining a liquid heating portion of an internal surface of the vessel, the liquid heating portion being located so as to be normally covered by liquid in use, a heater element comprising a resistive track applied to an electrically insulated surface of the substrate, a power control circuit operable to supply power to the heater element, at least one temperature sensor formed as an electrically resistive track on the insulated surface of the substrate, the circuit being operable to turn off the power in response to an excess temperature being sensed by means of the sensor, characterised by the or at least one of the sensors extending peripherally of the liquid heating portion and in proximity with the heater element.

Such an arrangement ensures that any tendency towards overheating of part of the liquid heating portion due to tilting of the apparatus is rapidly detected since it is the periphery of the liquid heating portion which will be first exposed during such tilting action.

Preferably the vessel comprises a pouring spout located in a front wall of the vessel, the liquid heating portion comprising a front portion proximal to the front wall and a rear portion distal to the front wall and wherein the substrate is provided with first and second sensors extending peripherally of the front and rear portions respectively.

Advantageously the liquid heating portion comprises left and right hand portions respectively to the left and right hand of the pouring spout and wherein each one of the first and second sensors is associated with a respective different one of the left and right hand portions so as to extend peripherally of that portion.

Conveniently the heater element extends in serpentine manner across the substrate such that the heating element is folded to define linear portions of resistive track which extend parallel to one another and wherein the first and second sensors are interdigitated with the linear portions.

An advantage of such an arrangement is that the heat generated from the heater element is distributed across the liquid heating portion to thereby avoid nucleate boiling of the liquid.

By interdigitating the sensors with the heating element, any localised overheating of the element can be rapidly detected.

In a preferred embodiment the power control circuit is operable to turn off power to the heater element in response to a difference in temperature between the first and second sensors being sensed.

Alternatively a plurality of temperature sensors may be provided on respective parts of the substrate and separately connected to the power control circuit, the circuit being operable to turn off power to the heater element in response to temperature above a threshold value being sensed by any one of the sensors.

Conveniently the power control circuit is constituted by a thick film printed circuit formed on the substrate integrally with the heater element and the temperature sensors.

In a preferred embodiment the vessel is a kettle for heating water, the internal surface of the kettle having a bottom surface portion constituted by an exposed surface of the substrate and the insulated surface of the substrate being external to the chamber.

Conventiently the temperature sensors are formed by a resistive track comprising a nickel based thick film ink.

Advantageously the heater element comprises a resistive track formed by two or more track elements following a common serpentine path in parallel spaced proximity to one another.

This assists in the even distribution of heat on the substrate and reduced the effects of current hogging causing overheating at the inner edges of curves in the heater element resistive tracks by dividing the

current into two or more track elements.

A preferred embodiment of the present invention will now be described by way of example only and with reference to the accompanying drawings of which:-

Figure 1 is a schematic view of the underside of a substrate having a heater element,

Figure 2 is a perspective view of a kettle incorporating the substrate and heater element of Figure 1,

Figure 3 shows an electrical circuit for controlling the power supply of the kettle of Figure 2, and

Figure 4 shows the underside of an alternative substrate having a heater element for use in a modified kettle of the type shown in Figure 2.

Apparatus in accordance with the present invention is shown in Figure 2 to comprise a vessel in the form of a kettle 1 having a body 2 formed of a plastics material. The kettle 1 has a base 3 comprising a steel plate substrate 4 which is peripherally bonded to the body 2. The kettle is provided with a thermally and electrically insulating layer (not shown) covering the base so as to insulate the base from any work surface onto which the kettle is placed in use. The base 3 has an underside 5 illustrated in Figure 1 which is coated with an insulating layer 6 on which is printed a heater element 7 in the form of a serpentine track of resistive material. The base 3 has an upper side 26 which constitutes a liquid heating portion of the internal surface of the kettle 1. Since the base 3 is located at the bottom of the kettle 1 it is normally covered by water when in use provided that the kettle is in its normal upright position.

The heater element 7 terminates in terminal pads 8 and 9 which are connected to a power supply circuit (not shown).

A first temperature sensor 10 in the form of a resistive track is also printed on the insulated layer 6 and extends in close proximity with the heater element 7 along two sides of the periphery of the heater element. The first temperature sensor 10 extends in serpentine manner so as to interdigitate with the folds formed in the heater element 7 and extends between first and second sensor terminal pads 11 and 12 respectively. A second temperature sensor 13 extends in like manner in close proximity with the remaining two peripheral sides of the heater element 7 and extends between third and fourth sensor terminal pads 14 and 15 respectively. The first and second temperature sensors thereby extend peripherally of the heater element in the plane of the insulated layer 6.

A resistor 16 forming part of a supply circuit is also printed on the insulating layer 6.

The first and second temperature sensors 10 and 13 are connected so as to form part of a sensor circuit 17 as shown in Figure 3. Resistors 18 and 19 act as potential dividers to generate a threshold voltage which is input to comparators 20 and 21. The outputs of comparators 20 and 21 drive an output device 22 which is connected to the power supply circuit such that an output signal is generated in response to there being a difference in resistance between sensors 10 and 13, the output signal being arranged to cut off power to the heater element 7.

In the above example the heater element 7 consists of two parallel lengths of track 23 and 24 which extend from terminal pads 8 and 9 respectively and are joined together at end terminals 25. Each length 23 and 24 provides 1200 watts of heating and is printed in Pd/Ag resistive material having a resistance of 140m ohm per square centimetre. The heating element 7 provides a power density of 0.75 watts per square millimetre.

The first and second temperature sensors 10 and 13 are printed from nickel based thick film ink with a temperature coefficient of resistance of approximately 8000 ppm and have a total resistance of 630 ohms at 20°C.

The kettle 1 is provided with a steam actuated thermal cut-out (not shown) which will turn off the power when the water within the kettle has boiled.

In use the kettle is filled or partially filled with water and power is supplied to the heater element 7. Heat generated by the heater element 7 is conducted through the steel substrate 4 and into the water which contacts the upper side of the base 3. This thermal transfer proceeds at a rate which ensures that the heater element 7 does not overheat and results in the temperature of the water being raised progressively to boiling point. The temperature of the water will eventually reach boiling point at which time the heat transfer results in the formation of steam which then activates the steam sensor and cuts off power to the heater element 7.

If during the heating process the kettle is tilted to an extent that part of the upper side of the base 3 is no longer covered by water, then the exposed part of the upper side 26 of the base 3 will rapidly become hotter than the remainder of the upper side. Typically tilting movement is likely to arise in use by a user pouring water from a spout 27 of the kettle in a tilting movement in which the kettle is supported by handle 28. Tilting in this direction will expose a part 29 of the upper sides 26 of the base 3 which is adjacent to the handle 28. At this part 29 will therefore rapidly tend to overheat thereby causing localised overheating of the substrate 4, the heater element 7 and the temperature sensors 10 and 13. As can be seen in Figure 1 the second temperature sensor 13 extends to a greater extent than the first temperature sensor 10 along this part of the periphery of the heater element 7 so that consequently the increase in resistance of the second temperature sensor will be greater than that of the first temperature sensor. A difference in resistance between the first and second temperature sensors 10 and 13 is then detected by the sensor circuit 17 resulting in the power to the heater element 7 be-

ing rapidly shut off thereby avoiding the destructive effects of overheating.

Tilting in the reverse direction will expose a different part 30 of the upper side 26 of the base 3 adjacent to the spout 27. In this instance it can be seen from Figure 1 that the first temperature sensor 10 will respond with an increased resistance which can then be sensed by the circuit 17.

Lateral tilting of the kettle 1 to the right or left will similarly result in overtemperature being sensed by the first or second temperature sensor respectively if corresponding right and left hand parts 31 and 32 respectively of the upper sides 26 are exposed.

The kettle 1 may alternatively include a modified substrate 50 as illustrated in Figure 4 which will be described using corresponding reference numerals to those of preceding Figures where appropriate for corresponding elements.

The substrate 50 is viewed from underneath in Figure 4 with respect to the normal orientation of kettle 1 so that the heater element 7 is formed on an outer surface of the substrate which is external to the chamber within which water is received for heating. A power control circuit 51 which incorporates the sensor circuit 17 shown in Figure 3 is also formed on the substrate 50 and includes discrete components which are surface mounted such that the substrate, the power control circuit, the heater element 7 and temperature sensors 10 and 13 together constitute a hybrid thick film circuit of integral construction.

In Figure 4 the heater element 7 extends between first and second terminal pads 8 and 9, pad 8 receiving a spade connector (not shown) for connection to a thermal fuse in line with the circuit.

The heater element 7 is formed as a resistive track having two main track elements 52 and 53 following a common serpentine path in parallel proximity. This arrangement has the advantage of reducing the effect of localised heating along the inside edges of bends formed in the tracks, a phenomenon often referred to as "current hogging". Between the parallel tracks 52 and 53, a relatively narrow resistance trimming track 54 is provided and terminates in a pad 55 which optionally can be linked to the pad 9 during assembly if it is required to reduce the total resistance of the heater element 7 to meet manufacturing tolerance.

The use of such a resistance trimming track 54 eases the required printing tolerance on the track elements 52 and 53.

In an alternative apparatus (not shown) any number of temperature sensors may be provided and each sensor provided with a respective sensor circuit for detecting over temperature of that respective sensor. An output signal is then generated to turn off power to the heater element in response to the or any of the sensors producing a signal indicative of the sensed temperature exceeding a threshold value. Such apparatus thereby relies on sensing the absolute value of temperature rather than the above described arrangement for sensing relative temperatures of the sensors.

The kettle may alternatively have a body formed of metal which may be bright finished steel or vitreous enamel for example.

Claims

1. Apparatus for heating liquid comprising a vessel (1) defining a chamber receiving liquid in use, a substrate (4) defining a liquid heating portion (26) of an internal surface of the vessel, the liquid heating portion being located so as to be normally covered by liquid in use, a heater element (7) comprising a resistive track applied to an electrically insulated surface (7) of the substrate, a power control circuit (51) operable to supply power to the heater element, at least one temperature sensor (11,13) formed as an electrically resistive track on the insulated surface of the substrate, the circuit being operable to turn off the power in response to an excess temperature being sensed by means of the sensor, characterised by the or at least one of the sensors extending peripherally of the liquid heating portion and in proximity with the heater element.

2. Apparatus as claimed in claim 1 wherein the vessel comprises a pouring spout (27) located in a front wall of the vessel, the liquid heating portion comprising a front portion (30) proximal to the front wall and a rear portion (29) distal to the front wall and wherein the substrate is provided with first and second sensors (11,13) extending peripherally of the front and rear portions respectively.

3. Apparatus as claimed in claim 2 wherein the liquid heating portion comprises left and right hand portions (32,31) respectively to the left and right hand of the pouring spout and wherein each one of the first and second sensors is associated with a respective different one of the left and right hand portions so as to extend peripherally of that portion.

4. Apparatus as claimed in any of claims 2 and 3 wherein the heater element extends in serpentine manner across the substrate such that the heating element is folded to define linear portions (23,24) of resistive track which extend parallel to one another and wherein the first and second sensors are interdigitated with the linear portions.

5. Apparatus as claimed in any preceding claim wherein the power control circuit is operable to turn off power to the heater element in response to a difference in temperature between the first and second sensors being sensed.

6. Apparatus as claimed in any of claims 1 to 4 wherein a plurality of temperature sensors are provided on respective parts of the substrate and are separately connected to the power control circuit, the circuit being operable to turn off power to the heater element in response to temperature above a threshold value being sensed by any one of the sensors.

7. Apparatus as claimed in any preceding claim wherein the power control circuit is constituted by a thick film printed circuit formed on the substrate integrally with the heater element and the temperature sensors.

8. Apparatus as claimed in any preceding claim wherein the vessel is a kettle (1) for heating water, the internal surface of the kettle having a bottom surface portion constituted by an exposed surface of the substrate and the insulated surface of the substrate being external to the chamber.

9. Apparatus as claimed in any preceding claim wherein the temperature sensors are formed by a resistive track comprising a nickel based thick film ink.

10. Apparatus as claimed in any preceding claim wherein the heater element comprises a resistive track formed by two or more track elements (52,53) following a common serpentine path in parallel spaced proximity to one another.

FIG. 1.

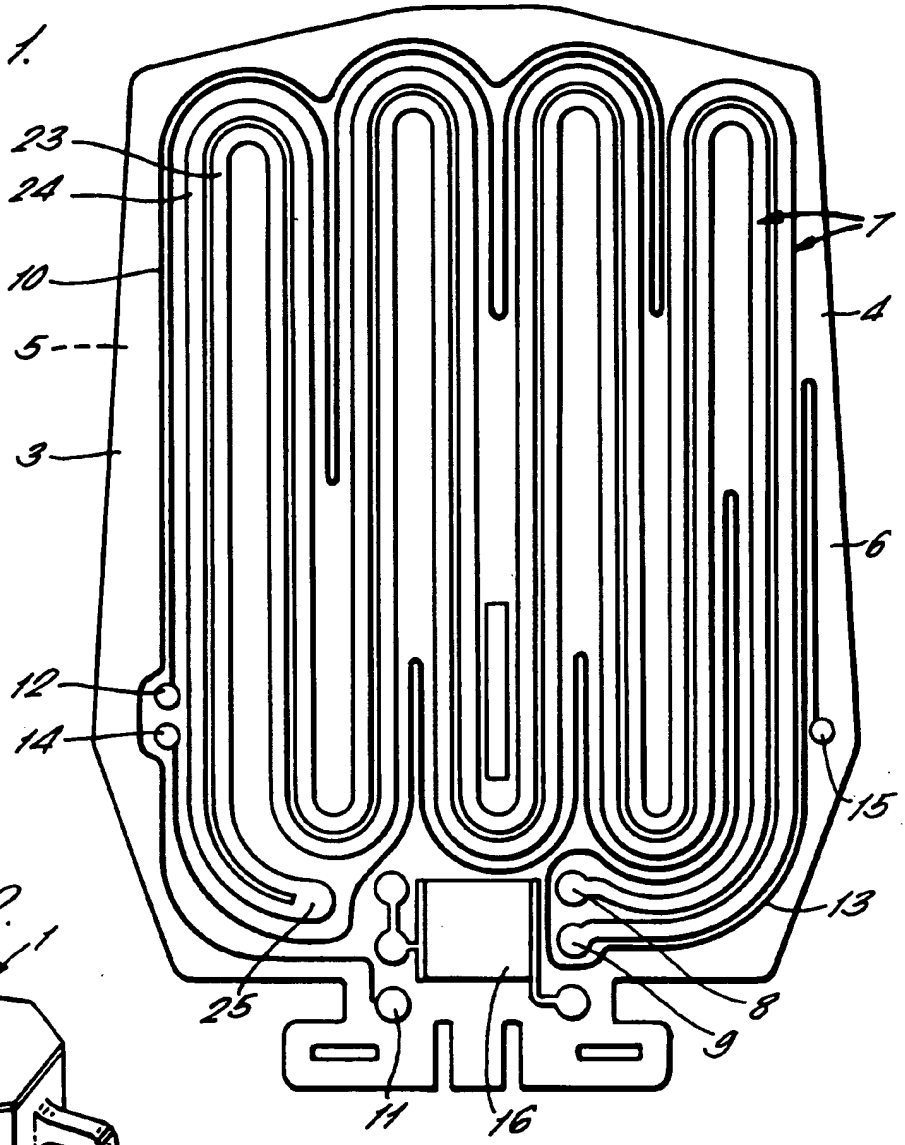


FIG. 2.

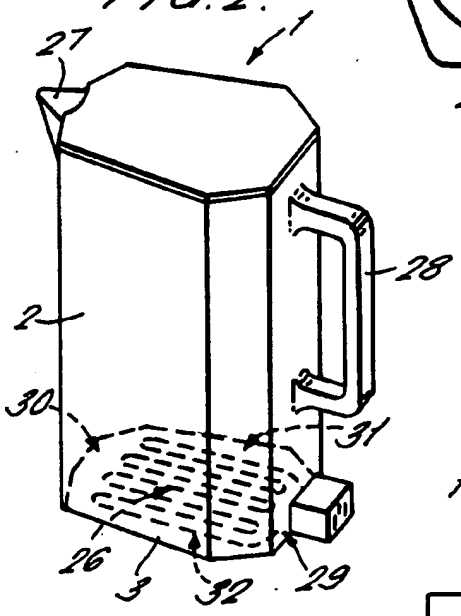


FIG. 3.

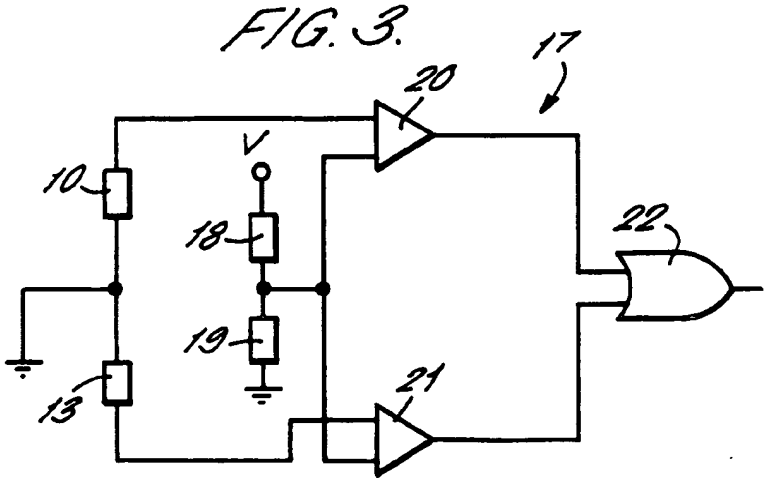
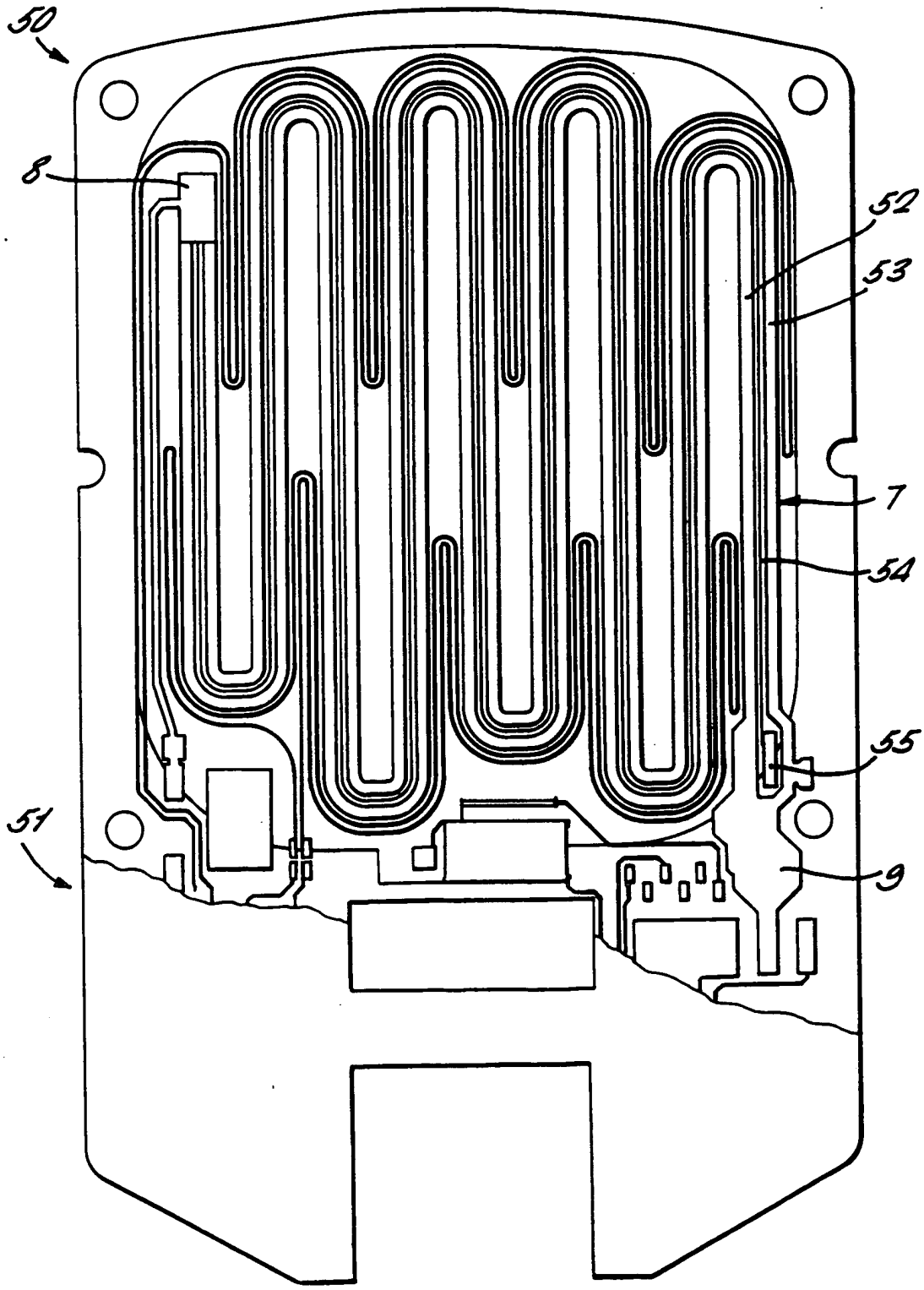


FIG. 4.



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EUROPEAN SEARCH REPORT

Application Number
EP 93 30 6409

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
X Y A	GB-A-1 548 406 (HUSQVARNA AB) * page 1, line 86 - page 2, line 14 * * figures 3,4 *	1 7-10 4	A47J27/21 H05B3/26
D,Y	EP-A-0 485 211 (IST LABORATORIES LTD.) * column 10, line 14 - line 58; figures 11,12 *	7	
Y	DE-U-89 02 013 (M. HOLTKAMP) * claim 1; figures 1,2 *	8	
Y	EP-A-0 286 217 (THORN EMI) * column 1, line 38 - line 50 * * column 4, line 17 - column 5, line 12; figures 1,5,6 *	9,10	
A	DE-A-35 45 445 (BOSCH-SIEMENS HAUSGERÄTE GMBH) * column 4, line 61 - column 5, line 5 * * abstract; figure 1 *	1,2,6	
A	EP-A-0 201 967 (FERRO ELECTRONIC B.V.) * page 3, line 25 - page 4, line 14; figure 3 *	6	TECHNICAL FIELDS SEARCHED (Int.Cl.5) A47J H05B
D,A	GB-A-2 153 190 (EMI LTD.)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	22 November 1993	SCHMITT, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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